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(54) Free piston-type compressor.

(57) A free piston-type compressor includes a piston (14) which is slidably fitted within a cylinder (15). A working gas compression chamber (22) is defined in the cylinder at one side of the piston. A balance chamber (21) is defined in the cylinder at the other side of the piston. A piston rod (13) is connected to the piston and extends axially out of the cylinder through the balance chamber, rather than conventionally through the compression chamber.

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The present invention relates to a free piston-type compressor, i.e. with a resonantly reciprocating piston.

In US-A-4,781,546 and 4,836,757 a conventional free piston-type compressor is described which has a piston reciprocably fitted within a cylinder. The piston is reciprocated within the cylinder by a motor and compresses on both sides so that on the opposite side to the compression chamber there is a balance chamber. Although the piston is freely reciprocated, the force of inertia of the piston which is produced by its compression movement is controlled by the recoil a coil spring and the compression load of the balance chamber.

However, since the compression chamber is positioned at the motor side of the piston and the balance chamber is on the side of the piston remote from the motor, a piston rod connected to the piston extends out of the compression chamber and is connected with the motor. It is thus necessary to prevent the high pressure gas in the compression chamber from leaking out along the outer surface of the piston rod. It is difficult to effect such sealing with a seal member.

In addition, inevitable clearances between the piston rod and valve plate cause the dead clearance of the compression chamber to be significantly large, with a consequential loss of volumetric efficency.

Furthermore, room for the usual valve mechanism including a valve plate, suction and discharge holes, and suction and discharge valves is limited since the piston rod extends out of the valve plate at its centre.

According to the invention, a free piston type compressor comprising a piston slidably fitted within a cylinder; a working gas compression chamber in the cylinder on one side of the piston; a balance chamber in the cylinder on the other side of the piston; a piston rod connected to the piston and extending axially out of the cylinder; a valve mechanism including a suction valve, a discharge valve and a valve plate and disposed on one end of the cylinder facing the working gas compression chamber; and a reciprocation power production means reciprocating the piston through the piston rod; is characterised in that the piston rod extends out of the cylinder through the balance chamber.

The accompanying drawing is a cross-sectional view of a free piston-type compressor in accordance with one embodiment of this invention.

The illustrated compressor includes closed casing 1 which is provided with inlet port 2 and outlet port 3. Supporting frame 4, which is disposed in closed casing 1, includes central shaft 41 with an axial bore, flange portion 42 protruding outwardly from the upper portion of central shaft 41, a plurality of leg portions 43 extending downwardly from the peripheral portion of flange portion 42 and cylindrical portion 44 extending upwardly from the peripheral portion of flange portion 42. Supporting frame 4 is attached onto the inner surface of closed casing 1 at its leg portions 43. Supporting frame 4 can be elastically attached onto the inner surface of closed casing 1 through a spring to absorb vibration.

Inner magnetic field core 8 is fixedly disposed to surround central shaft 41 and outer magnetic field core 9 which has magnetic field coil 10 therein is also fixedly disposed to surround inner magnetic field core 8 with a gap thereto. Inner and outer magnetic field cores 8 and 9, and magnetic field coil 10 composes a stator of a linear motor. Reciprocator 11 is composed of cylindrical magnets 11a, 11b and 11c which are connected with each other and is disposed in the gap between inner and outer magnetic field cores 8 and 9 to enable axial movement. Disc-shaped hub 12 which is U-shaped in cross section is connected to the lower portion of reciprocator 11. When alternating current is supplied to magnetic field coil 10, alternating magnetic field occurs on magnetic field cores 8 and 9, and reciprocator 11 thus reciprocates.

Piston rod 13 is slidably disposed in the axial bore of central shaft 41 and its lower portion is connected to disc-shaped hub 12, of which the peripheral portion is connected to the lower portion of reciprocator 11. Piston 14 is connected to the upper portion of piston rod 13.

Cylindrical member 15 is fixed on flange portion 42 of supporting frame 4. Piston 14 is slidably fitted in cylindrical member 15. A valve mechanism is fixedly disposed on the upper portion of cylindrical member 15 and is composed of valve plate 18, which includes suction hole 181 and discharge hole 182, suction valve 19 and discharge valve 20. Flange portion 42, cylindrical member 15 and the valve mechanism defines a cylinder. The cylinder is divided into balance chamber 21 and working gas compression chamber 22. Balance chamber 21 is composed of flange portion 42, cylindrical member 15 and piston 14. Working gas compression chamber 22 is composed of cylindrical member 15, the valve mechanism and piston 14. Part annular groove 23 is formed on the inner wall surface of cylindrical member 15, and balance chamber 21 and working gas compression chamber 22 communicate with each other when piston 14 passes through groove 23.

Cylinder head 24 is attached to valve plate 18 and includes suction chamber 25 and discharge chamber 26, which communicate with working gas compression chamber 22 through suction hole 181 and discharge hole 182, respectively. Cylinder head 24 further includes communication hole 28 to communicate suction chamber 25 with inner cham-

ber 27 of closed casing 1 and communication hole 32 to communicate discharge chamber 26 with buffer chamber 31 which is defined by annularly extending and connecting flange portion 29 of cylinder head 24 to cylindrical portion 44 of supporting frame 4. Buffer chamber 31 is connected to outlet port 3 through connection tube 33 which is integrally formed with outlet port 3.

Annular seal members 34 and 35 are disposed adjacent to the upper and lower portion of central shaft 41, respectively, to seal a gap between the outer surface of piston rod 13 and the inner surface of the axial bore of central shaft 41. Spring 36 is disposed to surround the outer surface of piston rod 13 to maintain distance between flange portion 42 and piston 14 in balance chamber 21. Spring 37 is also disposed to surround the outer surface of piston rod 13 to maintain the distance between the lower end surface of central shaft 41 and hub 12.

The operation of a free piston-type compressor as mentioned above is described below.

Under no operation of the compressor, piston 14 is positioned in correspondence with groove 23 formed on the inner wall surface of cylindrical member 15 as shown in FIG. 1. At the present time, working gas compression chamber 22 and balance chamber 21 communicate with each other through groove 23. When alternating current is supplied to magnetic field coil 10, piston rod 13 starts to reciprocate upwardly and downwardly, and piston 14 also reciprocates upwardly and downwardly together with piston rod 13 in the cylinder.

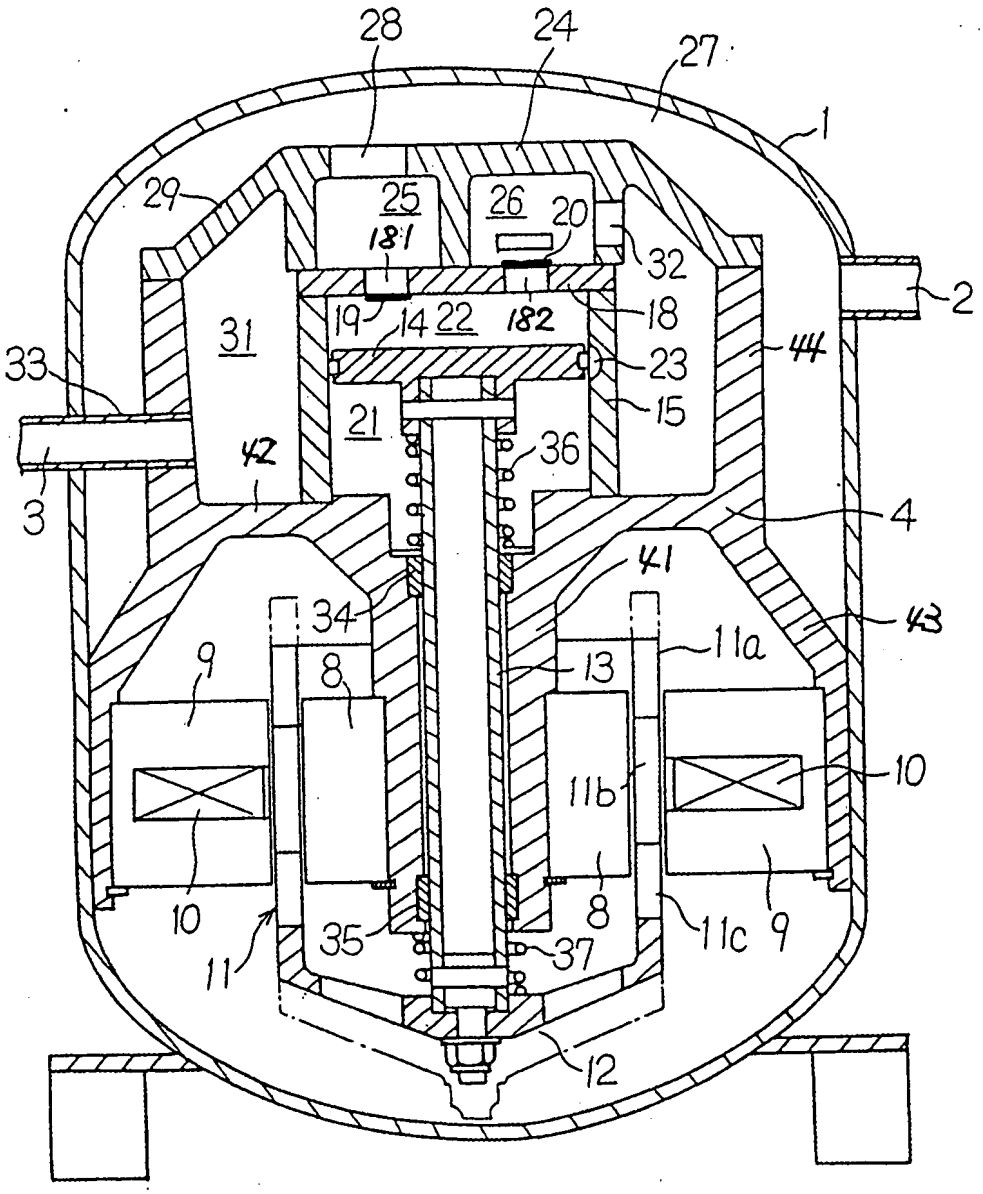
When piston 14 moves upwardly in the cylinder, the volume of working gas compression chamber 22 reduces gradually according to the movement of piston 14, and the working gas in chamber 22 is compressed. The compressed gas opens discharge valve 20 and is discharged to discharge chamber 26 through discharge hole 182. The gas in discharge chamber 26 flows out to an outside circuit through buffer chamber 31, connection tube 33 and outlet port 3. On the other hand, the volume of balance chamber 21 expands gradually according to the movement of piston 14, and the pressure in balance chamber 21 decreases. As a result, the pressure in balance chamber 21 becomes lower than the pressure in working gas compression chamber 22 and acts on the rear surface of piston 14 thereby to counterbalance the force of inertia of piston 14 moving upwardly, and prevents piston 14 from running against valve plate 18.

Contrarily, when piston 14 moves downwardly in the cylinder, the volume of working gas compression chamber 22 increases gradually according to the movement of piston 14, and the pressure in working gas compression chamber 22 decreases. Suction valve 19 is opened since the pressure in working gas compression chamber 22 is lower than the pressure in suction chamber 25. The gas in suction chamber 25 thus flows into working gas chamber 22. On the other hand, the volume of balance chamber 21 reduces gradually according to the movement of piston 14, and the pressure in balance chamber 21 increases. As a result, the pressure in balance chamber 21 becomes higher than the pressure in working gas compression chamber 22 and acts on the rear surface of piston 14 thereby to counterbalance the force of inertia of piston 14 moving downwardly, and prevents piston 14 from running against flange portion 18.

As described above, piston 14 may be prevented from running against valve plate 18 and flange portion 42 during operation of the compressor although piston 14 can move freely.

Claims

1. A free piston type compressor comprising a piston (14) slidably fitted within a cylinder (15); a working gas compression chamber (22) in the cylinder on one side of the piston; a balance chamber (21) in the cylinder on the other side of the piston; a piston rod (13) connected to the piston and extending axially out of the cylinder; a valve mechanism including a suction valve (19), a discharge valve (20) and a valve plate (18) and disposed on one end of the cylinder facing the working gas compression chamber; and a reciprocation power production means reciprocating the piston through the piston rod; characterised in that the piston rod (13) extends out of the cylinder (15) through the balance chamber (21).



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EUROPEAN SEARCH REPORT

Application Number

EP 92 30 2692

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-4 966 533 (UCHIDA) * column 6, line 44 - line 56; figure 1 *	1	F04B35/04
X	EP-A-0 028 144 (DAVEY) * page 2, line 27 - page 5, line 28; figure 1 *	1	
X	EP-A-0 014 817 (MAN DESIGN) * page 4, line 15 - page 5, line 16; figure 1 *	1	
X	GB-A-2 206 931 (NITTO KOHKI) * page 10, line 19 - page 17, line 19; figures 2-4 *	1	
X	PATENT ABSTRACTS OF JAPAN vol. 9, no. 57 (M-363)(1780) 13 March 1985 & JP-A-59 192 873 (NIPPON DENSO) 1 November 1984 * abstract *	1	
A	GB-A-2 224 340 (MITSUBISHI DENKI)		TECHNICAL FIELDS SEARCHED (Int. Cl.5) F04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 JULY 1992	GATTI C.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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